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13. ABSTRACT (Maximum 200 words)

The next generation of personal communications networks are expected to provide support for multimedia traffic (integrated transport of voice/video/data) -- accordingly, new spectrum allocations with larger bandwidth (broadband access) are being explored. Support of higher rates and heterogeneous traffic will require breakthroughs at level of network design. In this work, we focus on several signal processing aspects of advanced digital wireless transceivers for Code-Division Multiple Access (CDMA) systems for next generation broadband applications. Specifically, progress is reported on the design of efficient Multi-User (MU) detectors for CDMA that possess acceptable complexity-performance trade-off.

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FINAL PROGRESS REPORT
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Design Issues for Advanced Digital Wireless Networks

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1 Statement of Problem

The next generation of personal communications networks are expected to provide support for higher-rate, variable traffic classes (integrated transport of voice/video/data) — accordingly, new spectrum allocations with larger bandwidth are being explored. Support of higher rates for such heterogeneous traffic will require breakthroughs at level of network design, lead by new broadband access strategies. In this work, we focus on several signal processing aspects of design of advanced digital wireless transceivers for Code-Division Multiple Access (CDMA) systems for next generation applications.

A key component in improved link design in support of higher speeds is centered around the concept of Multi-User (MU) detectors for CDMA systems. While optimal MU detectors are desirable, they suffer from unacceptable complexity — hence ‘practical’ MU detectors with acceptable complexity-performance characteristics must be achieved prior to their consideration as candidate architectures. Accordingly, our research has centered around the theme of ‘pragmatic’ broadband digital receivers for CDMA systems.

Our initial work concentrated on enhancements to the Projection Receiver architecture (developed and reported by C. Schlegel and S. Roy). The Projection Receiver approach is computationally very efficient and has superior performance with respect to some other competing multi-user receiver techniques for CDMA. It lends itself to VLSI implementations and can be used in systems with long (pseudo-random) spreading codes or short (periodically repeated bit-length) codes.

Further, high-rate broadband systems will encounter frequency selective multipath fading channels, the severity of whose impact increases with the data rate. Thus MU CDMA detectors must

be further robustified to counteract such fading, which usually entails additional complexity. As before, our focus was the design of efficient CDMA receivers that preserve desirable features of adaptivity to the unknown channel (i.e., suitable for on-line implementation) and blindness (does not require training sequences).

Finally, another prospective candidate for future broadband wireless access is Orthogonal Frequency Division Multiplexing (OFDM) technology (in conjunction with CDMA) which has some important advantages over traditional single-carrier transmission techniques. We conducted some initial research on design issues for advanced OFDM receiver on similar lines to our work on CDMA receivers for multipath channels.

2 Summary of Results

In [1] below, an efficient algorithm for adaptive metric generation for the receiver for a coded, asynchronous CDMA was reported. Extensive simulations were performed to study the performance of this receiver with fixed, bit-length spreading sequences as well as long pseudo-random spreading sequences. As a result, elements of a pragmatic fully-digital receiver structure for asynchronous CDMA was established. Subsequent work on receiver design focussed on fading multipath channel scenarios which constitutes an outstanding design challenge due to the need for adaptive tracking of the channel parameters. We have developed efficient blind adaptive subspace detectors for both synchronous and asynchronous CDMA systems [4]. Comparisons with existing methods show that the proposed receivers have superior performance, while keeping moderate complexity. We have studied fast subspace tracking methods thoroughly, and taken the design of a signal subspace-based adaptive receiver one step further toward practical implementation.

Further in [2,3] results on adaptive algorithm choice and performance for DS-CDMA systems were investigated. While [2] is primarily a tutorial review of the state-of-knowledge regarding *adaptive* multiuser detection, [3] presented some new analytical insights into convergence rates and Signal-to-Interference-and-Noise Ratio (SINR) at convergence for a blind multi-user detector adapted using the Least Mean Square (LMS) algorithm. Specifically, it showed why an adaptive detector that is constrained to the signal subspace achieves superior performance in DS-CDMA systems to one that is not so constrained.

Finally in our initial research on OFDM, we have proposed a blind iterative receiver which jointly estimates the channel and symbols, utilizing the known partial Inverse Discrete Fourier Transform (IDFT) matrix and the Toeplitz structure of the channel matrix. It identifies a novel approach for using known information in achieving a superior OFDM receiver design, and points to interesting future research topics.

3 List of Publications

Journals

1. C. Schlegel, S. Roy, and P. Alexander, "Coded asynchronous CDMA and its efficient detection," *IEEE Trans. Inform. Theory*, vol. 44, no. 6, Nov. 1998, pp. 2837–2847.
2. T.-J. Lim and S. Roy, "Adaptive detectors for multiuser CDMA," *Wireless Networks*, vol. 4, no. 4, 1998, pp. 307–318.
3. S. Roy, "Subspace blind adaptive detection for multi-user CDMA," *IEEE Trans. Commun.*, 1999 (to appear).
4. Y. Song and S. Roy, "Blind adaptive reduced-rank detection for DS-CDMA signals in multipath channels," *IEEE J. Select. Areas Commun.*, Wireless Communications Series, 1999 (to appear).

Conferences

1. Y. Song and S. Roy, "Blind adaptive multiuser detection over ISI channels with channel estimation," in *Proc. 32nd Asilomar Conf. Signals, Systems, Computers*, Pacific Grove, CA, Nov. 1998, pp. 533–537.
2. Y. Song and S. Roy, "Subspace blind detection of asynchronous CDMA signals in multipath channels," in *Proc. SPAWC'99*, Annapolis, MD, May 1999, pp. 21–24.
3. Y. Song and S. Roy, "A blind reduced rank CDMA detector for multipath channels," in *Proc. 8th Commun. Theory Mini Conf., ICC'99*, Vancouver, BC, June 1999, pp. 62–66.
4. Y. Song, S. Roy and L. A. Akers, "Joint blind estimation of channel and data symbols in OFDM," *IEEE VTC 2000 Spring Conf.*, Tokyo, Japan, submitted July 1999.

4 Participating Scientific Personnel

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